Orographic and Fetch Limited Flows

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LONG TERM GOALS

Increase our scientific understanding of orographic and fetch-limited flows and apply this knowledge to improve our ability to predict the atmosphere and ocean circulation on the mesoscale, particularly in the coastal zone.

OBJECTIVES

The primary objective is to apply numerical models to gain a more complete understanding of mesoscale processes in littoral regions. Sophisticated 3-D mesoscale atmospheric and ocean models are used to study: i) orographic flows such as wakes, orographic precipitation, downslope windstorms and gravity wave breaking, and ii) fetch-limited effects in littoral regions such as internal boundary layers, expansions fans and marine boundary layer hydraulic jumps.

APPROACH

Our approach is divided into the following three components: data analysis, numerical model process studies, and theoretical development. In the data analysis component, we will make use of archived conventional, non-conventional, and special data sets from field experiments. We will use analysis techniques to blend these data to develop high-resolution data sets continuous in space and time which can be used in the other two components of our research. The process studies will use the Coupled Ocean/Atmosphere Mesoscale Prediction System (COAMPS), developed in the NRL 6.2 project Mesoscale Modeling of the Atmosphere and Aerosols (BE 35-2-18). COAMPS includes a nonhydrostatic atmospheric model and the NRL Coastal Ocean Model (NCOM). COAMPS will provide a mechanism for understanding and testing theoretical formulations concerning the interactions of various scales of motion and the mesoscale circulations caused by orography, the land-sea interface and fetch-limited effects. In the theoretical component, we will develop and test hypotheses for observed and modeled orographic and fetch-limited phenomena and utilize an adjoint of COAMPS to isolate initial condition sensitivity.

WORK COMPLETED

In the past year, we have used COAMPS to investigate the mesoscale dynamics of a variety of phenomena including previously undocumented wave clouds that form upstream of coastal barriers,

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transcritical flows, island wakes, tropical convection in the coastal zone, downslope windstorms, landfalling fronts and breaking gravity waves forced by steep coastal orography.

RESULTS

Special field data were collected to study the breakdown of gravity waves during the Mesoscale Alpine Programme (MAP). A mesoscale gravity wave climatology for the Alps was constructed using COAMPS simulations and served as a basis for designing the observing strategy for MAP. Analysis of quasi-linear and nonlinear gravity wave cases during MAP is ongoing. The land-sea surface roughness and heat capacity contrasts were found to vary diurnally controlling the convective response. The boundary layer effects on flow over 3-D mountains was studied for a cold front over topography, for which vertical mixing explains important departures from the inviscid case, and mountain waves, which are determined by the shape of the boundary layer. Island wakes were studied to examine the role of low-level wave breaking and sensible heating. Internal boundary layer dynamics were studied for a roughness jump. Diurnal effects on an expansion fan were documented along with the microwave ducting implications.

IMPACT

COAMPS has been used to gain a new understanding of the mesoscale dynamics and processes associated with a number of phenomena. A highlight of this body of work is a study of flow impinging upon coastal topography that results in a trapped shock-wave response, which ultimately forces lineal coastal wave clouds due to the strong vertical velocity. This study demonstrates the promising future capability of a high-resolution modeling system such as COAMPS in the coastal zone, and underscores the importance of topography in generating significant coastal mesoscale circulations. A second highlight is the studies that document the role of the boundary layer in the modulation of gravity wave launching and absorption of energy in the downstream stagnant layer. This conclusion was based on special field data during MAP, high-resolution non-linear COAMPS and linear model results. It is anticipated that these results may lead to substantially different approaches to the parameterization of wave drag in larger-scale models such as NOGAPS.

TRANSITIONS

Developments from this program will transition to an existing 6.2 program (PE 0602435N) for applications within COAMPS and for subsequent transition to Fleet Numerical Meteorology and Oceanography Center (FNMOC) and other potential sites for operational use. At this time no transitions have been identified.

RELATED PROJECTS

Related 6.2 projects within PE 0602435N include BE-35-2-18, Mesoscale Modeling of the Atmosphere and Aerosols, which focuses on the development of the atmospheric component of COAMPS, and 3523, which focuses on the development of an ocean model for COAMPS. A related 6.4 project within PE 0603207N is Small-scale Atmospheric Models (SPAWAR, PMW-185, task X-2342), which focuses on the transition of COAMPS improvements to FNMOC. Another 6.4 project, within PE

0603785N, Air/Ocean Model and Prediction System Development, which focuses on the development of a coupled data assimilation/forecast system for COAMPS.

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